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Performance Measurement of GSTEB Protocol Using NS-2

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Abstract

The quick growth in the network multimedia equipment have allowed real-time digital services such as video conferencing, online games and distance education to grow on the conventional internet tasks. The Wireless Senor Network (WSN) has become a major area of research in the computational theory due to its wide range of applications. WSN is an emerging technology which is made up of thousands of low cost and low battery powered sensor nodes which are highly distributed with sensing, processing and communication characteristics. The sensor nodes have a limited battery power, and the battery replacement is not easy for WSN with thousands of nodes which makes the lifetime of WSN crucial. Protocols such as LEACH, HEED, PEGASIS, TBC and PEDAP are proposed in order to overcome the problems faced by the WSN networks. The GSTEB protocol improves the lifetime by 100% as compared with HEED. In this research work, a novel tree based routing protocol is proposed which constructs a routing tree using a process for each round, Base Station BS selects a root node and informs this selection to remaining sensor nodes in its vicinity. Subsequently, each node selects its parents by considering information of itself and its neighbour's information, thus making a dynamic protocol. The results of the research focuses on the Quality of Service parameters providing 0.115 Dead Node Ratio for 70 nodes, Routing Load 34 x 10^3 bits, 520J Total Energy Consumption WSN and Network Lifetime achieved is 1.6250 x 10^3 seconds.

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Keywords: Energy-balance, network lifetime, routing protocol, wireless sensor network.

1. Introduction

The development of Wireless Sensor Network (WSN) is motivated by military applications such as battlefield surveillance; today such networks are used in many industry and consumer applications such as industrial process monitoring and control, machine health monitoring and so on. WSN has gained worldwide attention in the recent years; WSN is made of few to several thousand nodes, where each node is linked to other sensor nodes. The sensor node has the typically several parts such as an external antenna, a processor and an energy source, usually a battery. The sensor nodes can sense the environment and based on some local decision can transmit the sensed data to the user. The sensor nodes have limited memory and power and they are typically implemented in difficult to access

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locations, battery is the main power source of the sensor. Secondary power supply harvests power from the environment such as solar panels and power backups may be added to the node. Depending on the application and type of the sensors used, actuators are required to be incorporated in the sensor nodes. The WSNs are divided into two major categories namely structured WSN and unstructured WSN. The unstructured WSN is one that contains a large collection of sensor nodes. Sensor nodes may be deployed in a master slave manner into the field. In structured WSN, all the sensor nodes are implemented in a pre-planned manner. The advantage of the structured WSN is that fewer nodes can be deployed with low maintenance and management cost. Fewer nodes can be deployed, since they are placed at specific locations to provide coverage while ad-hoc deployment can have uncovered region. WSNs have potential for many applications in scenarios such as military target tracking and surveillance, natural disaster relief, health monitoring, and hazardous environment exploration and seismic sensing.

The organization of the paper is as follows, Section II describes proposed work. Section III presents expected results followed by conclusion in Section IV.

1.1 Background

Wireless Sensor Network consist of a single Base Station and a number of wireless sensor nodes placed in the vicinity of the Base Station. The sensor nodes sense the data, process it and then forwards it to the Base Station. There are various routing protocols defined till date as shown in the diagram [1]

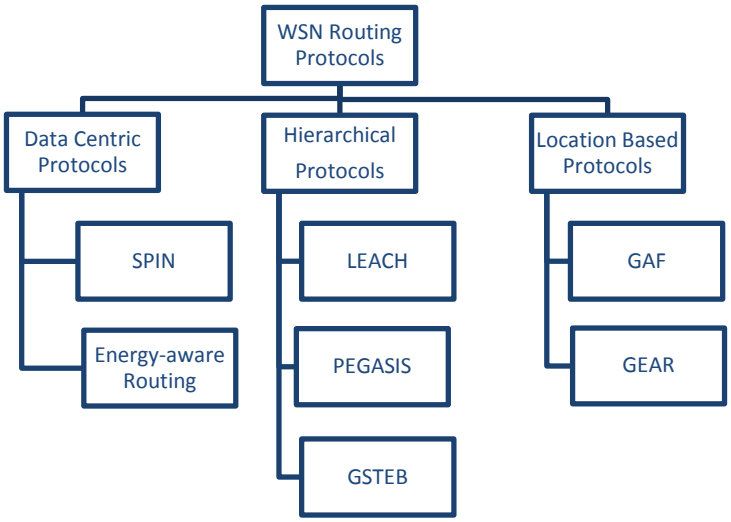

Fig. 1 Wireless Sensor Network Routing Protocols

The research work focuses on improving the Hierarchical Routing Protocols precisely on GSTEB (General Self-Organized Tree based Energy Balance Routing Protocol).

The existing GSTEB protocol builds a routing tree which helps to save energy of the Wireless Sensor Network which in turn increases the network lifetime. The simulation results for 100m x 100m area of 100 nodes with the Base Station situated at (50m, 150m) and the wireless sensor nodes having energy of 0.25J transmitting and receiving a packet of 2000bits shows that GSTEB performs 100 to 300% with respect to LEACH and PEGASIS.

The operation of GSTEB is broadly divided into:

- Initial Phase
- Tree Constructing Phase
- Self-Organized Data Collecting and Transmitting Phase
- Information Exchanging Phase

The proposed system deals with improving the tree constructing phase of the GSTEB protocol. The tree construction phase includes two algorithms; which are one-hop connectivity and self-organized tree formation. The one-hop connectivity approach are formed by a parent node and all nodes are at the distance of at most one-hops from the parent node. One-hop connectivity generalizes connectivity for a one-hop neighbourhood. A node is selected as a parent node if it has the highest connectivity and highest residual energy. One-hop connectivity based tree formation reduces the number of trees formation. The self-organized formation is the mobility based system. The node within a tree can able to move outside from its specified range. So the nodes which come outside from its range will form a self-organized tree and again it selects a parent node to transfer data, hence there will be no data loss. Hence selection of parent node based on one-hop connectivity and self-organized tree formation improves the network lifetime and reduces the communication cost and for effective data transmission in the sensor network.

1.2 Applications

The Wireless Sensor Network can be deployed in two ways such as the sensor positioned far from the actual phenomenon and secondly, several sensors that only perform sensing operation. The sensor node then transmit time series of the sensed phenomenon to the central nodes where processing takes place and data are fused. The various application [2] of the routing protocols in the Wireless Sensor Networks are as follows:

- Military Applications
- Environmental Applications
- Health Applications
- Home Applications
- Other Commercial Operations

1.3 Hierarchical Routing Protocols

There are several Hierarchical Routing Protocols [3] which increases the lifetime of WSN

a) **LEACH**: In this paper Heinzelman, W. Rabiner et al, has proposed LEACH [4] [5] (Low Energy Adaptive Clustering Hierarchy).In LEACH clusters are formed which reduces the energy significantly. The cluster head in LEACH protocol is selected by using a threshold value T (n). The LEACH protocol consists of two phases:

- Setup Stage
- Steady Stage

In Setup Stage, for a particular cluster one of the nodes becomes the cluster head (CH) while the others become sensor nodes. The sensor nodes transmit the sense data to the cluster head. In the Steady Stage each cluster head fuses the data sensed by the sensor nodes and transmits it to the Base Station for that particular round. The Steady Stage takes more time span compared to the Setup stage.

b) **PEGASIS**: In this paper Lindsey, Stephanie, et al, has proposed PEGASIS (Power Efficient Gathering in Sensor Information System. It is an improvement of LEACH. In PEGASIS [6] [7] each node transmits its data to its adjacent note and data gathering takes place. Data fusion results into less transmission of data between sensor nodes and base station. The data which is gathered from the sensor moves node by node and a designated node performs the data fusion and transmits to base station.

c) **HEED**: In this paper Y'Ossama, and S. Fahmy has proposed HEED [8] (Hybrid Energy Efficient Distributive Clustering Approach) in which cluster head is selected in wireless sensor network based on its residual energy. Unlike LEACH, random selection of cluster head is not possible since it decreases the lifetime. The cluster head must have less intra-cluster communication cost along with minimal residual energy. The intra-cluster communication cost represents the nodes neighbour and it is also useful for the nodes to decide to which cluster they belong. HEED is a proactive strategy with a base station and

moderate energy and it selects the best route with respect to residual energy. HEED exploits multiple transmission power levels thereby increasing the lifetime of the network.

d) **TEEN:** In this paper Manjeshwar, Arati and D. Agrawal has proposed TEEN [9] (Threshold Energy Efficient sensor Network) which works on Reactive networks. Generally sensor network are classified as Proactive networks and Reactive Networks. Proactive networks provide a periodic snapshot of important parameters. They are used in applications which help in monitoring the networks. Reactive networks reacts immediately to unwanted changes, these are used in critical applications where time plays an important role i.e. Real time applications. LEACH is a protocol for proactive network whereas TEEN is a protocol for reactive network. The TEEN protocol divides the cluster into hierarchy. It is 98% efficient than LEACH and 50% more stable. TEEN works on two modes:
   - Hard Threshold
   - Soft Threshold

2. Proposed Work

The Methodology proposed in this research work is based improving the GSTEB [10] protocol which in turn increases the network lifetime [11]. The above mentioned work is divided into various modules as follows:
- Initial Phase
- Tree Construction Phase
- Self-Organizing Data and Transmitting Phase
- Information Exchanging Phase
- Efficient Tree Formation Algorithm
- Analysis

2.1 System Architecture

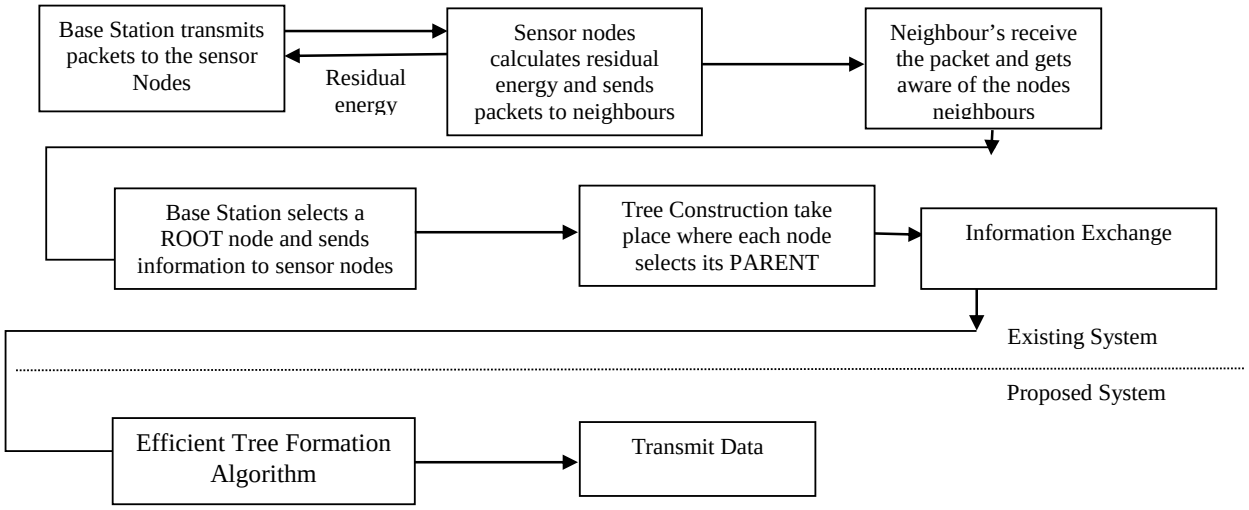

Fig.2 Proposed System Architecture

a) Initial Phase: The initialization of the network in which the energy efficient protocol will be deployed. The base station is considered to broadcast packet to 100 nodes in the network simulator environment in ns2. The sensor node receives the packet received from base station and computed residual energy. The node

transmits the packet which contains information about its residual energy to the neighbours which are in the vicinity.

b) Tree Construction Phase: The base station selects a sensor node as the root depending on the residual energy. The base station broadcast the selected nodes ID which is the root to all the nodes. Each node selects the parent which in turn will forward packet to root and the root will forward to the base station. If no parent is there in the vicinity of the node then node will send it directly to the base station.

c) Self-Organizing Data and Transmitting Phase: Each sensor node collects information to generate a data packet which needs to be transmitted to base station. After a node receives all the data from its child nodes, this node itself serves as a leaf node and tries to send the fused data in the next time slot. The first segment is used to check if there is communication interference for a parent node. In this segment, each leaf node sends a beacon which contains its ID to its parent node at the same time.

d) Information Exchanging Phase: Each node needs to generate and transmit a data packet in each round, before it exhaust its energy and die. The dying of any sensor node can influence the topography. So the nodes that are going to die need to inform other nodes. The process is also divided into time slots and in each time slot, the nodes whose energy is going to be exhausted will compute a random delay which makes only one node broadcast in this time slot. When the delay is ended, these nodes will try to broadcast a packet to the whole network. While all other nodes are monitoring the channel, they will receive this packet and perform an ID check. Then they modify their tables. If no such packet is received in the time slot, the network will start the next round.

e) Efficient Tree Formation Algorithm: The tree constructing phase includes two algorithm. They are one-hop connectivity and self-organized tree formation. The one-hop connectivity approach are formed by a parent node and all nodes are at the distance of at most one-hops from the parent node. One-hop connectivity generalizes connectivity for a one-hop neighbourhood. A node is selected as a parent node if it has the highest connectivity and highest residual energy. One-hop connectivity based tree formation reduces the number of trees formation. The self-organized formation is the mobility based system. The node within a tree can able to move outside from its specified range. So the nodes which come outside from its range will form a self-organized tree and again it selects a parent node to transfer data, hence there will be no data loss. Hence selection of parent node based on one-hop connectivity and self-organized tree formation improves the network lifetime and reduces the communication cost and for effective data transmission in the sensor network.

f) Analysis: Wireless Sensor Network analysis with respect to the GSTEB is done on the basis of Routing Load, Network Lifetime, Dead Node Ratio and Energy Consumption.

2.2 Expected Outcomes

Table 1. Simulation Model

SIMULATOR	**Network Simulator 2**
Number of nodes	Random
Topology	Random
Interface type	Phy. /WirelessPhy.
MAC Type	802.11
Queue Type	Drop-tail/Priority Queue
Antenna Type	Omni Antenna
Propagation Type	Two-ray Ground
Routing Protocol	AODV

Transport Agent	UDP
Application Agent	CBR
Initial Energy	100Joules
Simulation Time	50seconds

- Initial phase: Base station broadcasting packets to all the sensor nodes
- Tree construction phase: sensor nodes selecting parent.
- Transmission of the sensed data by the sensor nodes to the base station
- Information about the node which is about to get exhausted in terms of energy
- Efficient Tree Formation Algorithm which tries to improve the existing GSTEB protocol.
- Quality of Service parameters such as Routing Load, Network Lifetime, Dead Node Ratio and Energy Consumption.

3. Results

Considering a Wireless Sensor Network Fig. 3.a consisting of 70 nodes out of which node 0 is the Base station. The Base station broadcasts the packet to the remaining sensor node and the sensor node sends information about their residual energy to the base station. The Base Station selects node 56, Fig 3.b as the root node depending upon the residual energy. The sensor node selects a parent according to the residual energy which in turn will communicate with the base station, this scenario is depicted in Fig. 3.c.

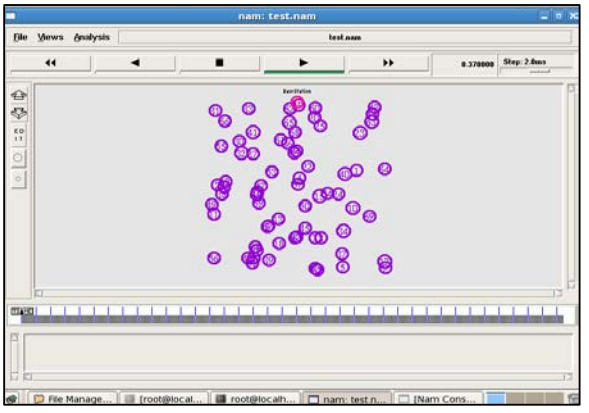

Fig. 3.a Initial Phase

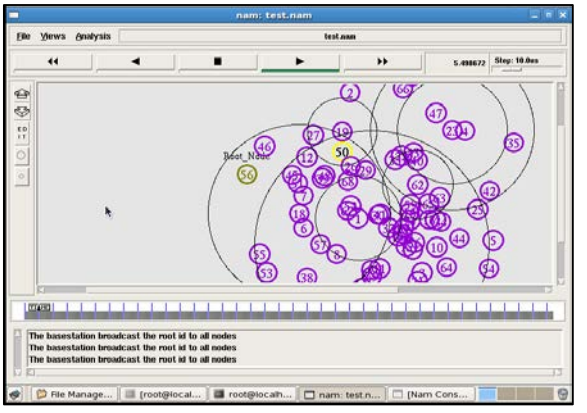

Fig. 3.b Tree Construction Phase

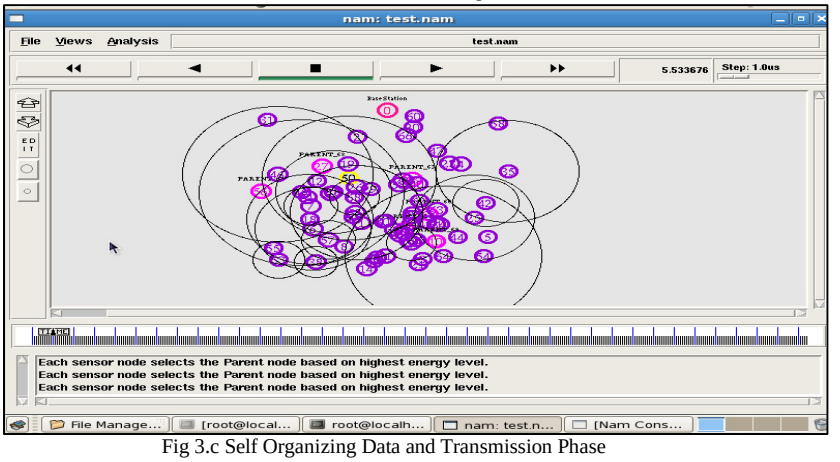

Fig 3.c Self Organizing Data and Transmission Phase

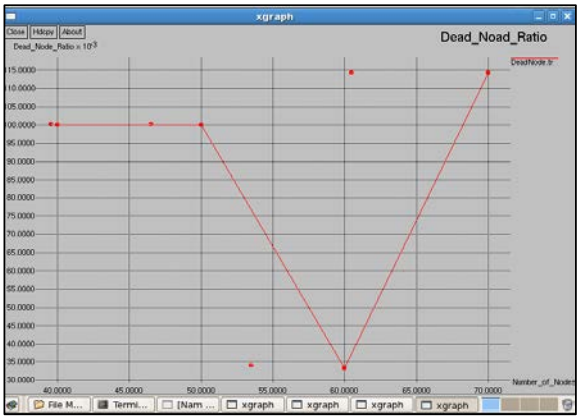

Fig 3.d Dead Node Ratio

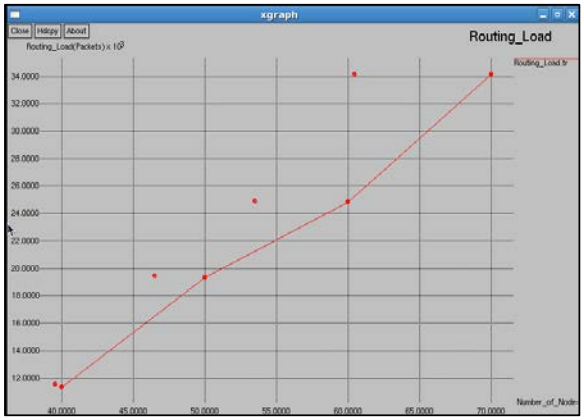

Fig 3.e Routing Load

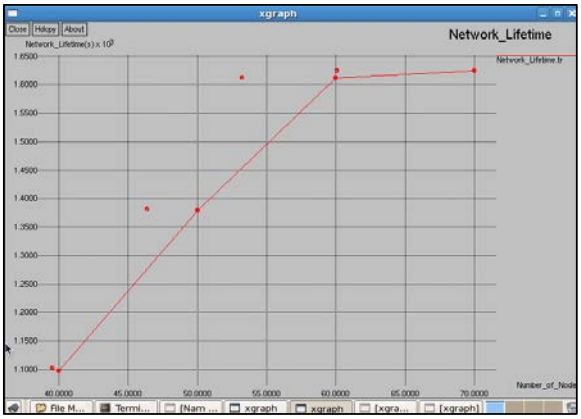

Fig. 3.f Network Lifetime

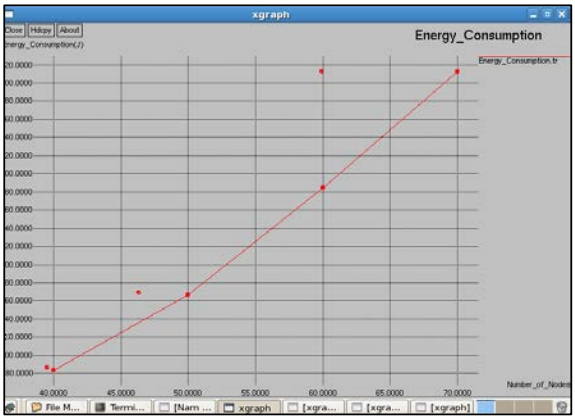

Fig. 3.g Energy Consumption

Fig 3.d depicts 0.115 Dead Node Ratio for 70 nodes in WSN. The routing load for 70 nodes is 34 x 10^3 bits packets. In Fig 3.d.The Energy Consumption graph Fig. 3.g for 70 node depicts the energy consumed by the WSN is 520J. The Network Lifetime is depicted in Fig. 3.f for 70 nodes is 1.6250 x 10^3 seconds. The Network lifetime defines the time when the death of the first nodes occurs. The future scope includes enhancing the above Quality of Service parameters such as Network Lifetime, Dead Node Ratio, Routing Load and Energy Consumption.

4. Conclusion: Wireless Sensor Networks have intrinsic and distinctive features rather than traditional networks. They have many different constraints, such as computational power, storage capacity, and energy supply. The proposed protocol applies tree based topology and introduces the load balancing scheme in GSTEB. Routing protocol separates network into more number of clusters, then by means of distance, and it constructs a routing tree for each cluster. In routing tree, most number of children for cluster nodes is determined. A general self-organized tree based routing protocol is enhanced with efficient tree formation technique which is based on two approach such as one-hop connectivity and self-organized tree formation in which parent node is selected based on highest connectivity and highest residual energy reduces the communication cost and increases the network life time and achieves effective data transmission in the sensor network. Proposed protocol manages load balancing, using routing tree, node's neighbours' average queue length and residual energy of nodes as parameters. The effectiveness of the protocol is validated by simulation.

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